✓ Antenna array $\Rightarrow$ • gain ↑

• Diversity Gain $\Rightarrow$ • multiple input
                                                streams

16 streams $\Rightarrow$ diversity gain

{
  • Contact them on Teams
  • Send email
 • Approach teaching office
}
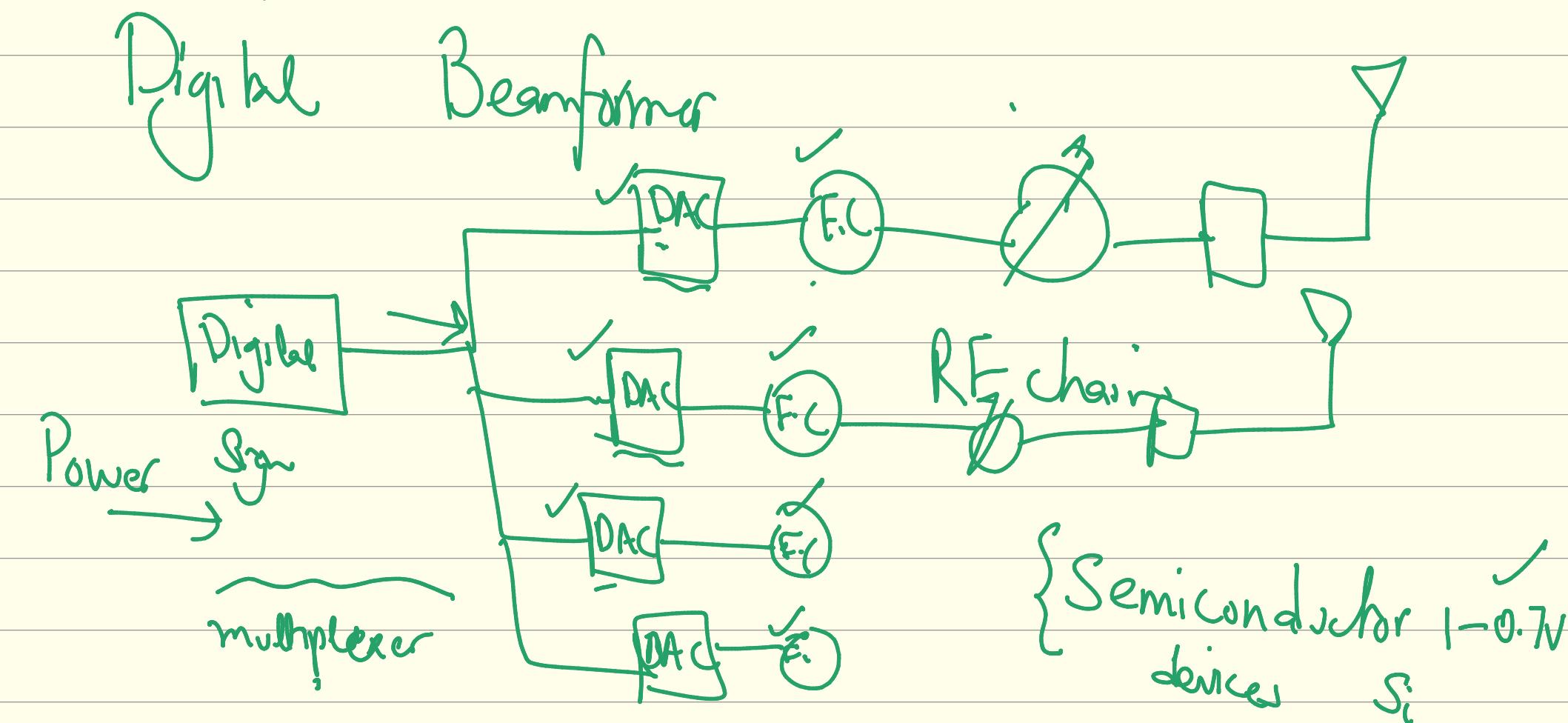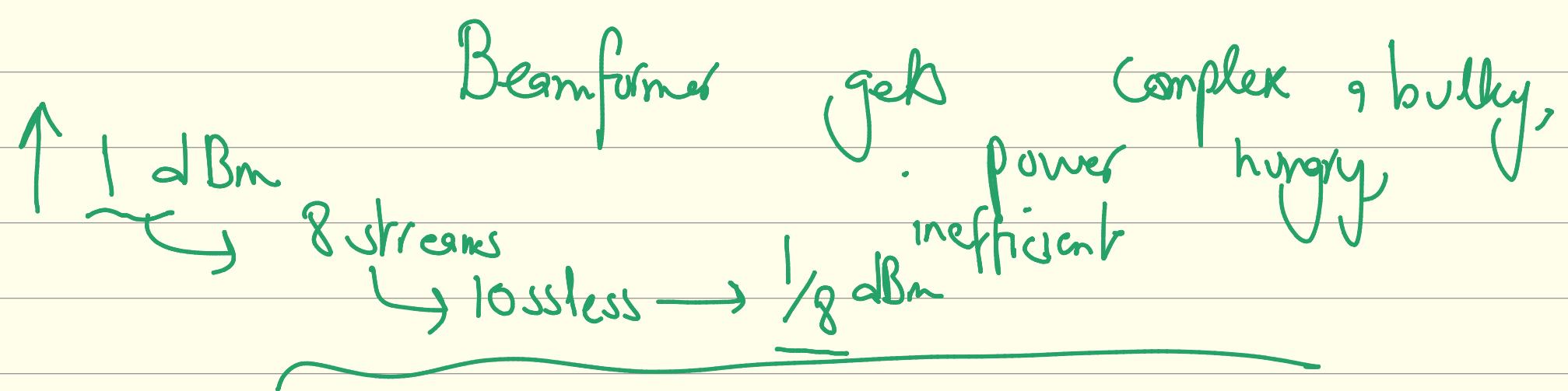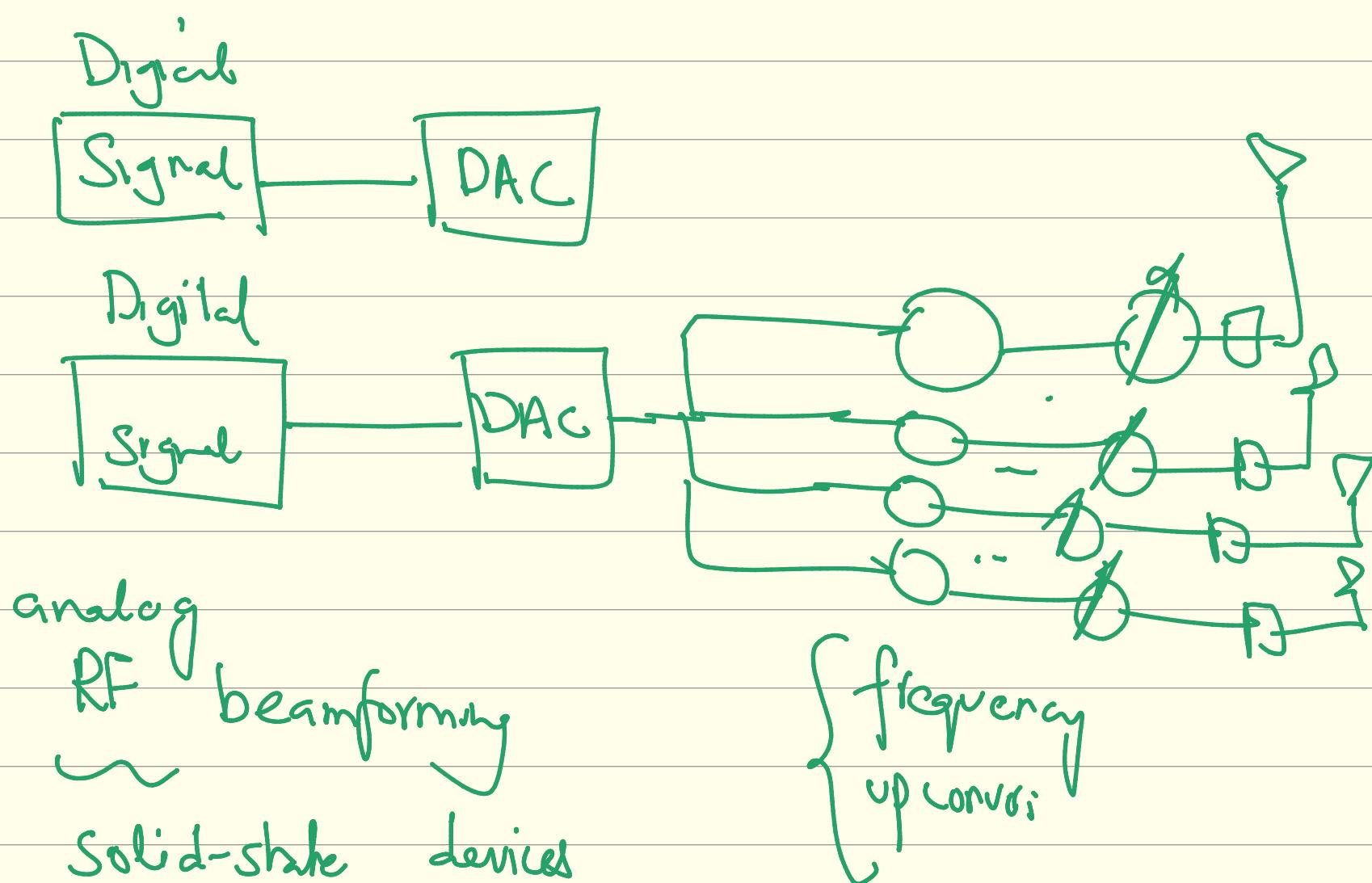
Tx → Rx

Received reliably

OFDM

→ Subcarriers

MIMO $\Rightarrow$ S/N   S/I

↑   Channel   ↑SINR   Capacity

Analog Beamforming

Digital
[Signal] — [DAC]

Digital
[Signal] — [DAC] — frequency up conver

analog
RF beamforming
Solid-state devices

Beamformer gets complex & bulky,
power hungry,
inefficient

↑ 1 dBm
        → 8 streams
            → lossless → 1/8 dBm

Digital Beamformer

[Digital] [DAC] — (F.C) — RF chains
Power Sgn
multiplexer

{ Semiconductor 1 - 0.7V
  devices   Si

Mostly used in RF and μ-wave
(< 7 GHz)
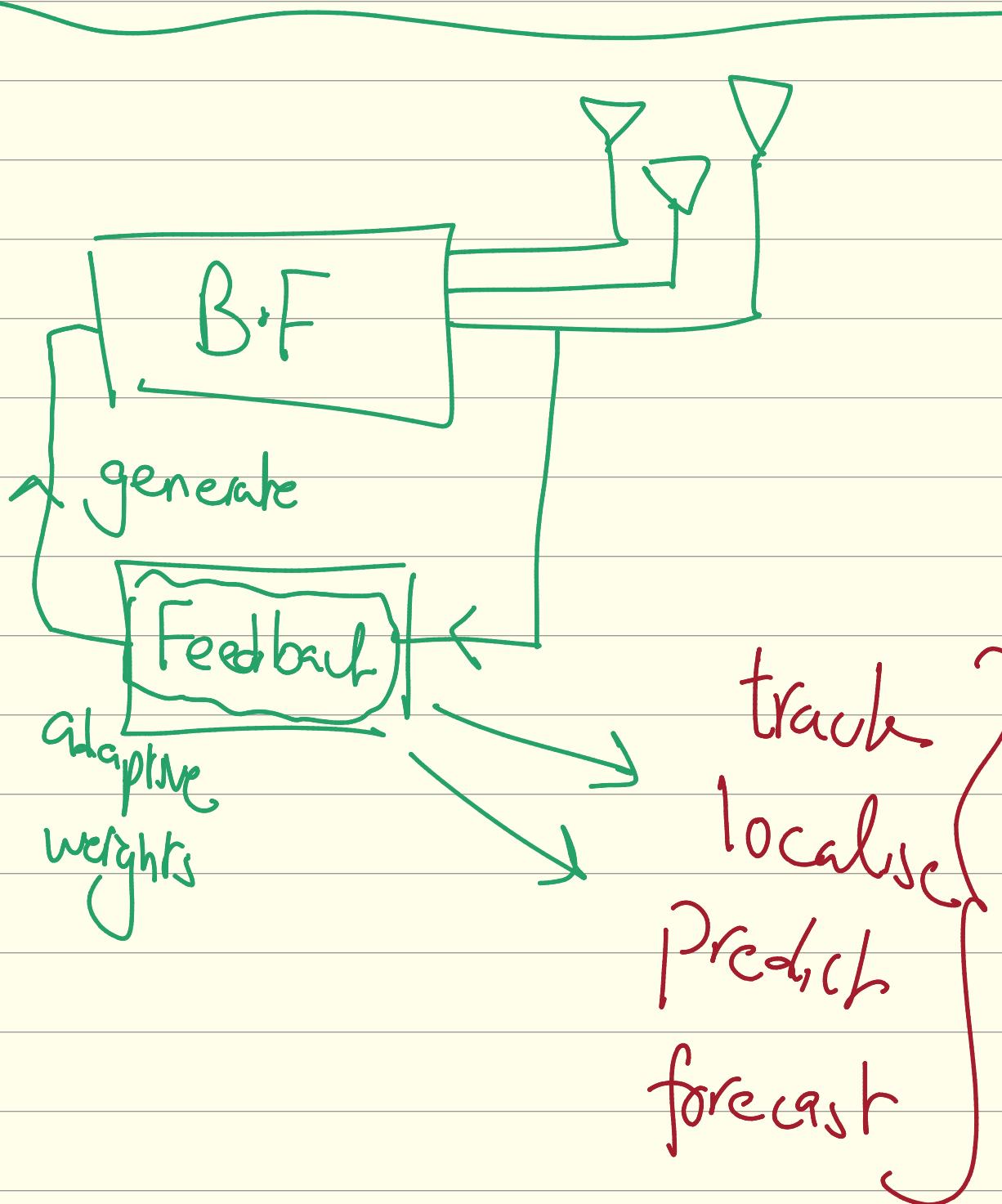
each
RF chain has their own components !!

64 x 64
8 x 8 → 64 RF chains

mmWave
↳ 512 x 512

B.F

generate

Feedback

adaptive
weights
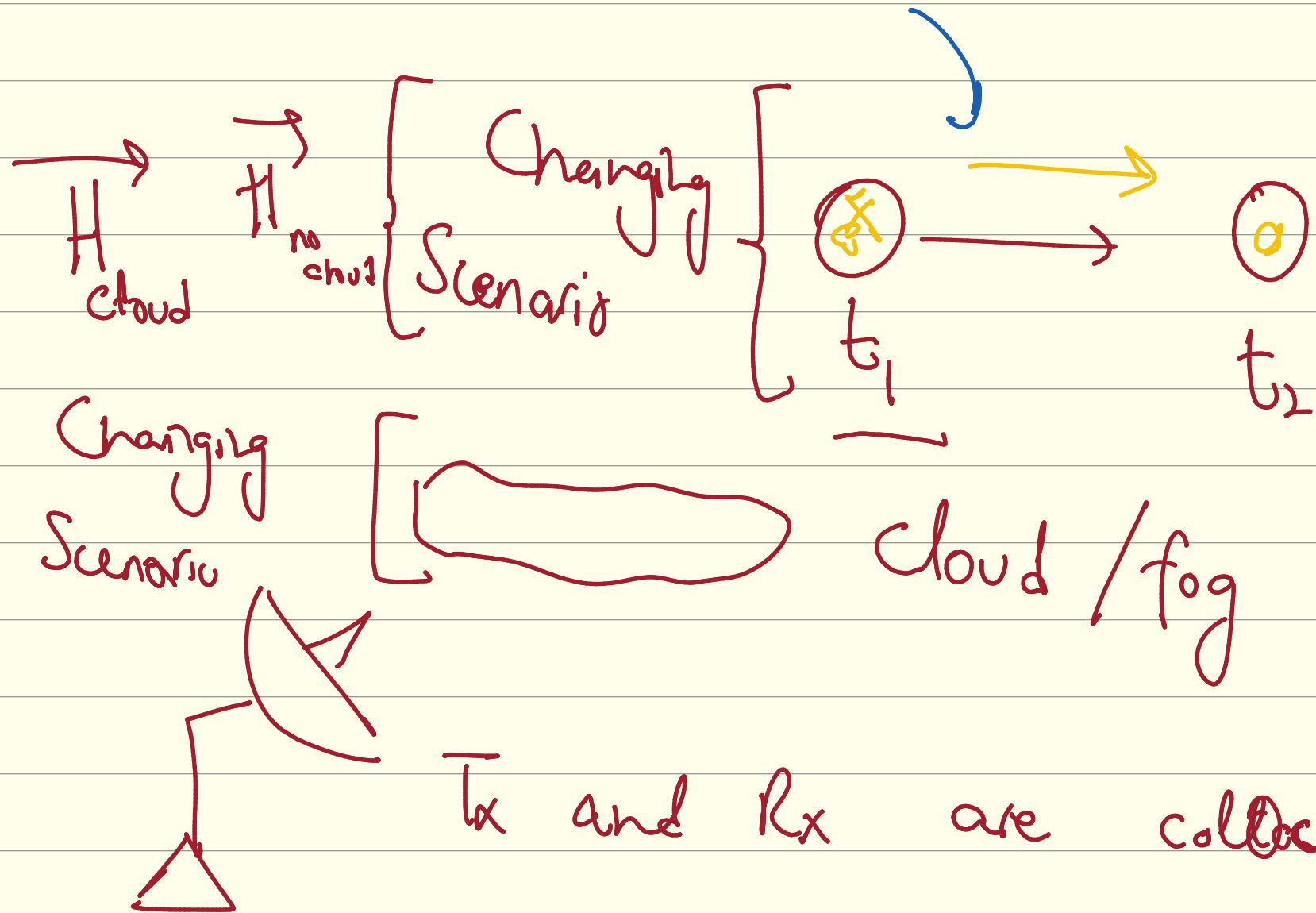
track
localise
predict
forecast

Sam Sampling rate of the system

$\rightarrow$ $\vec{H}_{cloud}$ $\vec{H}_{\substack{no \\ cloud}}$ $\left[\begin{array}{c} \text{Changing} \\ \text{Scenario} \end{array} \right.$ $\left\{ \begin{array}{c} \text{Changing} \end{array} \right.$ $\left\{ \begin{array}{c} f \longrightarrow \\ t_1 \end{array} \right.$ a t_2

Changing
Scenario

cloud / fog

Tx and Rx are collocated

Tracking Mechanism

Variances in Channel
typically slow

Pilot Signal Calibration